PRELIMINARY EXPERIMENTS OF OPENSIM PERFORMANCE EVALUATION FOR VIRTUAL DESIGN STUDIOS

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Abstract. This paper presents a technical performance evaluation of OpenSim as an alternative platform to Second Life, for virtual design studios. A number of issues that are critical for conducting virtual design studios were investigated through a series of tests and reflections from a Visual Training class. A performance test was also carried out in order to test server load against computer memory. These findings will provide valuable understanding to academics looking to use similar environments to Second Life for virtual design studio.

Keywords. 3D virtual worlds; OpenSimulator; virtual design studios; performance evaluation.

1. Introduction

In the field of Architectural Design Education, there have been researches about using 3D virtual worlds notably Second Life in Design and Design Education (Abdellatif and Calderon, 2007; Hernández Ibáñez and Barneche Naya, 2007; Tan and Lim, 2010). We have conducted virtual collaborative design studios in Second Life since 2008 (Gu et al, 2009; Nakapan et al, 2009). Our students were able to collaborate across the continents on design projects. Nevertheless, it was identified during the collaboration that Second Life has the following limitations, which have significantly compromised the establishment of virtual design studios, and limited students' design and learning activities in the studios. These limitations include:

- Initial set up cost is 700USD, with maintenance cost of 1,770USD per year (Educational/Non-Profit Discount will be removed from January 1, 2011 (Har-

rison, D.,2010)),
- an island size is limited to 256*256 sq.m.,
- the maximum number of concurrent users is 100 avatars per island, with effective number being only 30-40 avatars,
- the maximum number of prims allowed on an island is 15,000. However, only half of the maximum number is recommended for efficiency,
- the largest size of each prim is 10 meters,
- an image file or texture upload costs 10L each (around 1.45 cent),
- creating user account in bulk is prohibited.

In 2007, Linden Lab has released its viewer source code. Consequently, OpenSimulator, often referred to as OpenSim has emerged as an open source server platform for hosting virtual worlds. Further, it provides much greater flexibility in customizing the virtual worlds that were not possible previously in Second Life. Since then, OpenSim, even though in its early development stage, has been applied in the practice of virtual worlds, i.e. OSGrid ("Open-Simulator grid list", 2010). Recently, it has gained popularity among academics as an alternative to Second Life (Hu, 2010). It has the potential to open up new opportunities for design and collaboration since users, at lower cost, can have more control over the environment, such as creating and owning more islands, customizing the islands such as changing the shape and elevation of land (terraforming), building limit and access right, enriching designs in the virtual worlds such as having free upload of texture files, etc. A recent study on the topic "Comparing OpenSim with Second Life" (2009) has identified that OpenSim has strength and potential over Second Life, regarding cost and object building. However, these issues are not adequately explored, especially in the context of conducting virtual design studios. The user requirements for these studios are quite different from average users' of the virtual world. Therefore, this paper looks into specific issues of OpenSim that are related to virtual design studios, i.e. effectiveness in setting up such platform and changing environments in the virtual world. Our investigation evaluates and demonstrates how OpenSim can be used as an alternative platform for virtual design studios, through experiments and our experiences from a Visual Training class in OpenSim. The findings will provide valuable understanding to academics looking to use similar environments to Second Life for virtual design studios.

2. Background: System architecture of OpenSim

Standalond mode V.S. Grid Mode: OpenSimulator can operate in one of the two modes: standalone or grid mode (cf. Figure 1) ("OpenSimulator Configuration", 2010). In the standalone mode, a single process handles the entire simulation, which consists of region simulator and backend services (user,

asset, inventory, …). In the grid mode, a common service can be run on one machine, while region simulators can be run on other machines using the same set of common services. The standalone mode is easier to configure. However, the grid mode is scalable according to the number of users. An address of a simulator is referred to as a URI (Uniform Resource Identifier).
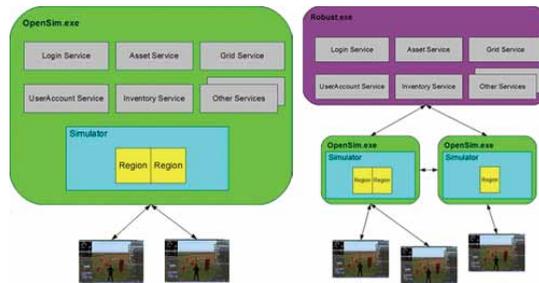

Figure 1. System Architecture of OpenSim: Standalone mode v.s. Grid mode (illustration adopted from opensimulator.org)

Hypergrid can be thought of as a virtual world hyperlink ("The OpenSim Hypergrid", 2010). It is an extension of OpenSim, which can be applied either in the standalone mode or the grid mode. It allows a seamless transfer of agent between sims. Thus a user logins on to his sim and can transfer to another sim while having his own set of inventory.

3. OpenSim performance evaluation for virtual design studios

This paper aims to examine the effectiveness of OpenSim as an alternative platform for virtual design studios. Based on a list of issues identified from our previous design and teaching experiences in Second Life, we conducted a series of lab tests to investigate the following technical issues in OpenSim:

    a.   Issues related to server setup, configuration and performance

       1.   Setting up OpenSim on common lab PCs,
       2.   setting up a web interface to facilitate the creation of user accounts,
       3.   linking to another Sim using Hypergrid,
       4.   changing maximum prim limit allowed on each island,
       5.   server performance test (this issue will be explored in Section 4).

    b.   Issues related to changing environments in the virtual world

       1.   Creating a mega-region (continuous islands merging together),
       2.   importing archives (terrain, island, and inventory),
       3.   creating a group of users,
       4.   dividing land,

5. creating large prims,
6. uploading texture files.

These issues are likely to be encountered by both the average users of virtual worlds, and students in virtual design studios. For issues related to server setup and configuration, one may adjust its environment in order to suit the purpose of the design studio according to available resources, i.e. making sure the server can handle a given number of avatars, and the students not building beyond the limit of available RAM, etc. For issues related to changing environments in the virtual world, one may change environments to suit each assignment, i.e. changing the terrain form according to the purpose of the assignment, providing enough parcels for students to build on, etc. This section will first briefly introduce the Visual Training class and its outcomes, followed by the lab tests and/or experiences from the Visual Training class.

3.1. THE VISUAL TRAINING CLASS

The Visual Training class was offered to 15 first year architectural students during October 2010 - January 2011. The objective of visual training is for students to develop the skill and understanding of artistic composition theories, starting from the arrangement of 2D elements and developed into more complex 3D designs. This small-scale class with simplified design and modelling tasks is a perfect vehicle allowing us to evaluate some of the technical performance issues of applying OpenSim in design education and preparing us for setting up full-scale virtual design studios scheduled for June 2011.

Figure 2. Three assignment examples from the Visual Training class

By the end of November 2010, three assignments were implemented by the students (cf. Figure 2). The first one is called "A star's avatar" in which students were asked to use modelling and graphic design tools in OpenSim to create avatars resembling a star or celebrity. The second assignment is called "Crop circle"; the students designed a 2D visual pattern with dots, lines and planes. The third assignment is called "From 2D to 3D", each student was

given images of a floor plan and four elevations of a simple house. They were then asked to design and simulate a house using the native design and modelling tool in OpenSim. These three assignments utilised a range of design skills and allowed us to test a wide range of design and modelling tools in OpenSim for supporting design in virtual design studios. The assignments show that students have developed and demonstrated basic skills in design and modelling using OpenSim.

3.2. ISSUES RELATED TO SERVER SETUP AND CONFIGURATION

1. Setting up OpenSim on common lab PCs. OpenSim can be run on two platforms, (1) Window with Microsoft .NET framework and (2) Unix-Mono. The set up test was done on two common lab PCs (Window XP, Intel Core2 Quad@2.33GHz, 4GB of RAM) located at the lab of Rangsit University. The versions of OpenSim tested in the lab were both an official version (currently 0.7.0.2) and a spin-off version called Diva Distro (currently r13981) ("Downloads for diva-distribution", 2010). This latter version distributed as Standalone Hypergrid pre-configured, was found easier to set up and update.

2. Setting up a web interface to facilitate the creation of user accounts. Diva Distro is also delivered with a built-in web interface called Wifi. The Wifi supports (1) account creation, optionally controlled by the administrator, (2) configurable default avatars for new accounts, (3) account updates by both users and the administrator, (4) account deletion by administrator, (5) password recovery via email, and (6) simple user inventory management. For the Visual Training class, students were asked to register their account on the Wifi webpage. After approval from the administrator, all students were able to login to the simulator.

3. Linking to another sim using Hypergrid. Hypergrid is an alternative way of scaling the standalone sims since running an OpenSim in the grid mode requires at least two servers. It also allows avatars moving from one sim to another.
A test has been done linking three standalone sims together, two lab PCs and a sim running on a home server. Three avatars from different sims then were able to meet successfully on a particular sim.
4. Changing maximum prim limit allowed on each island. We have experimented with limiting the number of prims allowed on each island via RegionConfig. ini file. Even though this feature is available on OpenSim, it is found nonfunctional, since students could build beyond a given limit, which can significantly slow down the navigation and collaboration in virtual design studios.

3.3. ISSUES RELATED TO CHANGING ENVIRONMENTS IN THE VIRTUAL WORLD

Creating a mega-region. Similar to Second Life, a regular size of a region on OpenSim is 256*256 sq.m.. However, a larger region can be achieved by combining different standard regions. Such a region is called mega-region, which has to be in rectangular or square shape, either 2*2, 2*3, 3*3, ... The support for large regions in virtual worlds is essential for large-size virtual design studios, and design projects that require large sites. Setting up a mega-region follows the rules below. Regions will have to begin at South West and end at North East. The position of a region is identified by its Cartesian coordinate (x,y). And a different region needs a different port. For example, the centre of the grid is considered as the coordinate of the first region (1000,1000), the region name is SW, and its port 9000. A 2*3 simulator was designed and successfully implemented for the Visual Training class.

Importing archives. *Changing the terrain form of an island using .raw files*: An island's shape in OpenSim can be changed by uploading a different .raw file to the system. For the Visual Training class, we have used a flat terrain file, since it was easier to construct on.
Importing an island using .OAR files: An entire island (its terrain, objects, scripts, …) can be imported or saved using .OAR file (OpenSim Archive). For the purpose of the Visual Training class, an island from OpenVCE project provided by the University of Edinburg (Tate, A., et al, 2010) was used in order to quickly setup the virtual campus. It provides an ambient space of a virtual campus, with buildings, exhibition areas, educational items, and a large auditorium where online lectures take place.
Importing inventory items using .IAR files: An inventory folder can be imported to OpenSim using .iar file. It can be very useful for beginner students because a collection of design and other useful virtual worlds elements (objects, textures, landscape items, clothing, etc.) can be provided to each student for them to begin with. It is found that a large .iar file can make the server unstable.

Creating a group of users. A group in OpenSim allows users in the same group to contact each other and share resources. A group can be created and students can join the group at no cost (it costs 10L in Second Life). A group module was implemented and tested in the class, which has been proven effective.

Dividing land. Land of a large area in OpenSim can be divided into parcels as small as 16*16 sq. m.. They can then be sold or given away to individual users via a system of Estate. This capability is very important for different students

to have different control rights over their own sites on a shared island within a virtual design studio. However, the division of the land should still be carefully coordinated. For example, in an assignment from the Visual Training class ("crop circle"), when students were given the right to divide and claim land themselves, it can become quite chaotic. The parcels were not of the same size, overlapping each other. In another assignment ("from 2D to 3D"), lands were already centrally divided into small parcels before being assigned to students. In the latter case the site is better organised, but can also become quite static. The merely square or rectangular parcel shapes can sometimes limit students' design possibilities.

Creating large prims. Prims in OpenSim could be created as large as 100 meters, using other viewers (Imprudence Viewer, Hippo Viewer,...) as opposed to the limit of 10 meters when using Second Life viewer. Students therefore have more opportunities and increasing flexibility in design and modelling.

Uploading texture files. Due to the costs associated with texture upload in Second Life, in our previous collaborative design studios students did not have adequate experiments on applying textures in enriching designs; some were limited to other free design elements such as colours and transparency only to explore design options. Textures can now be uploaded into OpenSim at no cost. Students could freely explore the use of textures and modify them as frequent as necessary in their design. Some lecture slides were also uploaded into inventory as textures and then showed on the virtual screens to the class.

4. OpenSim server performance test and results

OpenSim server performance is a very complex issue. It can be affected by a combination of the following matters: the number of prims on a region, number of regions, number of concurrent avatars, network quality between server and viewer, RAM, processor, etc. So far there is no precise information about the recommended hardware specifications ("OpenSimulator Performance", 2010). A number of concurrent users that the server can handle is also a critical question. In our case, we characterise "active users" as avatars who model, communicate and collaborate, navigate, ... constantly. To evaluate the performance of the server, we organised a case study to test the OpenSim server load against memory, to see the number limit of avatars/prims in relation to Frisby's evaluation (Frisby, 2009).
The test environment for the case study was our lab PC server (Window XP, Intel Core2 Quad@2.33GHz, 4GB of RAM, MySQL database). We used the latest Diva Distro as an OpenSim platform. The experiment involved using a

server of 3*3 regions (nine islands), active users built the maximum number of prims on one region after another until they all lagged (avatars could no longer move):

1. The 30 active avatars logged in into the system with 2 observer avatars.
2. The 30 active avatars gathered on SW island. They built 17,773 prims. The system lagged.
3. The 30 active avatars gathered on S island. They built 10,057 prims. The system lagged.
4. The 30 active avatars gathered on Central island. After tp, 3 avatars logged out unexpectedly. They built 5,012 prims. The system lagged.
5. Only 17 avatars could tp to SE, all the rest had to logout and re-login. The 30 active avatars gathered on SE island. They built 15,614 prims. The system lagged.
6. Most avatars could not tp to NE island, they had to logout and re-login. They built 54 prims. Then a server error was observed.
7. The experiment ended.

Table 1. Memory consumption of OpenSim in the server performance test

Description	Memory (MB)
A base cost of 200mb	200
Size of all textures in an average region is around 50mb: 50mb * 9 regions	450
30mb per 1,000 primitives	
– SW (17,773 prims)	533.19
– S (10,057 prims)	301.71
– C (5,012 prims)	150.36
– SE (15,614 prims)	468.42
– NE (54 prims)	1.62
– N, W, NW, E	-
50mb per concurrent user and double the sum if running under Mono (50mb*32 concurrent users .)	1,600
	3,705.3MB (3.62 GB)

After a calculation based of Adam Frisby's description, the system consumed 3.62GB of RAM. The server however, had 4GB of Ram installed, with 3.49GB of RAM left after deduction of those consumed by the OS. The performance test results (cf. Table 1) echo and extend Frisby's evaluation to provide a rough

calculation for memory consumption in using OpenSim. And the server can effectively handle 32 avatars, if there were not excessive amounts of prims on the region. The result repeated our earlier experiment on the same server using SQLite database and an earlier version of OpenSim, which handled 25 avatars. These results show that, while a later version of OpenSim seems to handle more concurrent avatars, the number of maximum prim limit is closely related to the memory. Consequently, one can predict that with twice as much RAM, one could expect twice as much prims and textures. However, this presumption of linear progression still needs confirmation. As for the texture, according to Liang, Motani and Ooi (2008), the median texture size over all three regions in their research was 95 KB. We can assume that 450Mb. of RAM can handle around 4,850 textures, which can cost up to 70USD in Second Life – not so significant saving.

5. Summary and the future

This paper presents a series of preliminary experiments to evaluate the technical performance of OpenSim for virtual design studios. Overall, based on a small-scale class with simplified design and modelling tasks, OpenSim shows potentials to serve as an alternative platform to Second Life for virtual design studios with no additional cost on the platform. In our case, this is a saving of 20,700 USD per year due to the switch from Second Life to OpenSim. OpenSim responded satisfactorily to most of the issues investigated in the Visual Training class. The open source nature of the platform also provides academics and students with greater control over the virtual environments. It is this increasing level of customisation and flexibility that distinguish OpenSim from current virtual world platforms and will potentially improve the design and learning experiences in future virtual design studios. The platform will be applied to a full-scale design studio scheduled for June 2011 - broader and more in-depth issues will also be explored.

However, being in its infancy stage, some of the features, such as setting prim limitation for a region did not work. Nevertheless, Diva Distro was proved to be very effective for a small-scale design and modelling class, and with future refinements we believe these flaws will be overcome. Our performance evaluation can provide indications for academic institutes to plan and scale the simulators according to their available resources.

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